Improving First Graders' Speed and Accuracy with Addition Facts to 20

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Abstract

The purpose of this study was to help first graders improve their speed and accuracy with addition math facts to 20 through the use of a variety of intervention strategies. The study was conducted with 21 first grade students with a range in their ability to solve addition math facts quickly and accurately. The measurement tool used to assess mathematics fluency was a teacher created math fact test. The null hypothesis that students who practice addition facts at home/school and participate in the online Fastt Math program will not significantly improve their performance in accuracy and speed was not supported. All groups improved their performance and there was no significant difference in performance between the groups.

CHAPTER I

INTRODUCTION

Mathematics fact fluency is an important skill for students to master in order to aid in their development of higher-order mathematical thinking skills (Sun & Zhang, 2011). Beginning as early as Kindergarten, students are introduced to a variety of strategies in order to solve problems using addition and subtraction. Building automaticity with arithmetic facts to 20 allows students to efficiently and effectively apply a fact that they have mastered in order to solve more complex problems (Kling, 2011). Mastering addition facts by the end of second grade provides students with a base in order to continue their mathematics fact skills with multiplication and division. Today in schools, students in upper level grades are still struggling to master addition and subtraction facts, which affects their ability to solve higher level problems and be successful as they continue their mathematics education.

In mathematics education, students are taught a variety of strategies they can apply to solve mathematics problems. In first grade, students learn to count up or count back, draw a picture, use different tools such as a part-part-whole mat or number line. Students understand the importance of using these strategies and apply them when solving problems; however, having the automaticity to solve basic addition problems up to 20 allows students to solve higher-level problems in the future and begin to master more advanced mathematics concepts, including multiplication and division.

In first grade, it is vital to provide students with exposure to addition and subtraction facts and with opportunities to practice and hone these skills in order to be successful later in their education. Early in first grade, students use strategies to solve basic addition problems such as 2 + 5. While it is appropriate to apply these strategies, as mathematics becomes more complex, it is

important for students to recognize and solve basic problems automatically without having to draw a picture or count up from a number. In order to be successful in mathematics, it is imperative for students to be successful in basic addition facts to 20.

This study examines several intervention strategies to determine if one strategy or a combination of strategies will help students master addition facts to 20. With proper implementation of addition fact strategies and practice, students will develop this skills which is essential to becoming successful in mathematics education.

Statement of Problem

Many students have difficulty retaining addition, subtraction, multiplication, and division facts. The purpose of this study is to determine which mathematics fact intervention will improve students' accuracy and automaticity in solving basic addition math facts to 20.

Hypothesis

The null hypothesis is that students who practice flash cards at home/school and participate in the online FASTT Math program will not significantly improve their ability to solve addition facts to 20 with accuracy and speed (hypothesis 1); and the groups with additional interventions at school will not show more growth (hypothesis 2). The three groups are organized in similar ways so there are no substantial differences among the groups other than the strategy being implemented during the intervention done with the teacher. Pre-test and the post-test results for all students will be compared to determine the amount of growth.

Operational Definitions

The dependent variable in this study was the number of addition facts to 20 that students can solve accurately in a given amount of time. Basic addition facts are those whose sums go up to 20. These facts should be solved mentally to help students as they begin to solve more complex

problems. The dependent variable is defined as the number of addition problems students can correctly solve on the post-test compared to the pre-test.

The independent variables of this study were the intervention groups implemented. Three different intervention groups were implemented during the study. Groups were determined through the use of a pre-test in order to determine students' abilities and develop groups with multiple ranges of ability. All groups were provided flash cards to practice each night at home. All students spent 30 minutes a week using the program FASTT Math. Group A met three times a week for 15 minutes to learn and play different games where students solved addition problems to 20. Group B met with the researcher 3 times a week to practice flashcards. Group C acted as a control and did not meet in a group within the school or with the teacher; instead, this group practiced flashcards at home and used FASTT Math for 30 minutes during the week.

CHAPTER II

A REVIEW OF LITERATURE

This review of literature explores various interventions as well as examples of other studies used to improve speed and automaticity when it comes to arithmetic facts. Section one provides a definition and overview of mathematics fact fluency. The importance of mathematics fact fluency and how mastery of these skills relates to success in mathematics throughout a student's career is discussed in section two. Section three provides information regarding the development of student's mathematics fact skills, followed by the effects of using engaging activities when teaching fact fluency to students. This section also reviews differences between various activities used in teaching mathematics facts, such as technology versus direct instruction. The final section is a review of interventions and strategies that can be used to improve fact fluency for struggling students.

Definition of Mathematics Fluency

Mathematics instruction is one of the core subjects taught in United States public schools (Smith, Marchand-Martella, & Martella, 2011). Becoming proficient in mathematics is an important goal in the early stages of a student's educational career and provides a foundation for other demands of schooling in later years. The National Council of Teachers of Mathematics (2010, p. 1) defines fact fluency as "integral elements of national math standards by which at the end of second grade, students should master basic addition and subtraction facts."

Mathematics fact fluency is a critical skill by which one retains the ability to automatically recall facts (Sun & Zhang, 2001). Mastery of addition, subtraction, multiplication, and division fluency provides students with a confidence and aids in their development of higher-order thinking skills and mathematical learning (Sun & Zhang, 2001). According to

Skarr, Zialinski, Ruwe, Sharp, Williams, and McLaughlin (2014), mastery of a basic fact is being able to state the problem and answer it within two seconds. Other sources define fluency with facts by noting it as "the efficient, appropriate, and flexible application of single-digit calculation skills and is an essential aspect of mathematical proficiency" (Baroody, 2006, p. 22). Without developing arithmetic act fluency skills, students do not have the foundation to comprehend higher level mathematical concepts.

Developing fluency in arithmetic facts focuses on rote memorization of facts in which students develop and use mathematical strategies with the goal of finding an efficient and effective way to apply a known fact to an unknown fact (Kling, 2011). For example, if students knows the sum to 5 + 5=10, they can use the strategy of making ten to solve problems such as 5 + 6 or 5 + 8. Developing these skills allows students to develop a "toolbox" that can be used when attempting more challenging problems. Kling (2011) states that students who struggle to develop mathematical fluency rely on less complex forms of thinking such as counting, where students begin with the first addend and count until they have added the second addend.

Importance of Mathematical Fact Fluency

There are many reasons why it is important for students to develop mathematics fact fluency. Fluency in basic computation skills provides the foundation for students to apply other mathematical applications including money, time, and problem-solving skills to solve higher level computation and word problems (Smith et al., 2011). Skarr et al. (2014) discusses how the mastery of addition facts is a critical skill needed for students to effectively progress to more advanced stages of the mathematics curricula. Automaticity and addition fact mastery allows students to solve more advanced math problems, such as story problems. The ability to recall basic addition facts strengthens students' mathematical abilities, mental mathematics, and higher

order mathematical learning. Without these skills, students will have difficulty performing more advanced operations (Sun & Zhang, 2001).

Development of Arithmetic Fact Fluency

In order to develop efficient computational strategies, students need to cultivate the necessary skills to decompose and recompose numbers in a variety of ways. According to Kling (2011), having the ability to be efficient with facts and committing usable facts to memory are two of the essential components to mathematics fact fluency.

There are two key components when it comes to mathematics fact fluency. The first is efficiency. Students should be able to recall facts accurately. The second is speed, with students needing to be able to recall facts quickly. While these two components allow a teacher to recognize arithmetic fact fluency in a student, it is important to understand the difference between efficiency and speed as fluency requires both. A student who recalls arithmetic facts in a short period of time does so with more speed, whereas a student who takes a few seconds to recall the fact is working through the problem mentally using a strategy demonstrating efficiency (Kling, 2011).

Becoming fluent in arithmetic facts is not only about being able to recall the answers, but is also about the students' ability to use this knowledge in flexible ways. Having the skill to efficiently answer arithmetic facts allows students to use these skills to determine unknown arithmetic facts as well (Kling, 2011). Mastery of basic arithmetic facts is imperative to students to have success in grades K-12 (Skarr et al., 2014).

The Effects of Engaging Activities and Mathematics Fact Fluency

Student engagement is defined as a student's investment and effort directed at learning, understanding, or skills and crafts that academic work supports and promotes (Bodovski &

Farkas, 2016). Student engagement is comprised of three components: learning work habits, cognitive behaviors, and emotions. Learning work habits involves students actively participating in the learning activity, being persistent when completing tasks, consistently completing their work, and challenging themselves in learning endeavors. Students who put their full attention into a task and use problem-solving skills in their learning demonstrate cognitive behaviors. The emotions component of students' engagement includes the students showing enthusiasm with a task and developing an interest in math work (Bodovski & Farkas, 2016).

Guerrero and Palomaa (2012) found that when first grade students were using methods from single-digit addition and applying those strategies to addition problems with two or more elements, they used strategies beyond simple fact mastery and combined other strategies. In doing so, they began to develop rich intermediary stages in mathematical understanding, which provides students and teachers with opportunities to discuss problem-solving approaches and develop further conceptual understandings.

Providing students with rich and engaging activities in mathematics allows them to develop deeper understanding of the skills and concepts they must apply to them. Many studies have been conducted using a variety of engaging mathematics practices in order to enhance students' learning of particular skills. In these studies, the activities selected allow the students to connect emotionally with the work, as explained by Bodovski and Farkas (2016). Building enthusiasm and interest in students is key in teaching math skills and working towards mastery of them, including fact fluency.

Interventions

Flashcards

Flashcards can be used to help children master basic arithmetic facts and have been a common method of fact skill practice in education. This method, however, is often found to be applied in an unsystematic manner and the efficacy of this task is not clear (Skarr et al., 2014). The use of direct instruction (DI) flashcard procedures provides a systematic way to introduce students to basic arithmetic facts using flashcards. In one study, students were presented with 15 flashcards where 12 of the facts were already mastered and the other 3 were not mastered. Flashcards were shown to students at a fast pace and students needed to respond within a given time period. The DI flashcard method has been shown to improve students' basic arithmetic fact mastery for students ranging from elementary to high school levels. This technique has also been effective for students with behavior disorders, intellectual disabilities, learning disabilities, and students with attention deficit disorders (Skarr et al., 2014).

Games

Games may also be used to teach and practice basic fact skills and fluency. The study by Skarr et al. (2014) study also used a racetrack mathematics problem game wherein students were given a board with different mathematics problems on each space. The goal of the game was to travel around the spaces and answer the problems correctly. DI flashcards, combined with the racetrack problem game did prove to be successful in improving students' fact fluency (Skarr et al., 2014). The study combined two different activities, which engaged students at varied levels of mastery and growth was shown in each student's ability to answer basic fact problems.

Whitney, Hirn, and Lingo (2016) conducted a study in which students who exhibited challenging behaviors and were struggling in math participated in The Great Leaps math

program. This program is a fluency building mathematics program. In it, lessons are provided for teachers to use that are concrete, using manipulatives that are representational, as well as the strategy of drawing pictures to solve problems.

Once students demonstrate an understanding of the concrete and representational lessons, they are introduced daily to a short lesson, followed by a minute-long oral or written math fact practice session, which allows the teacher to keep track of progress. The use of rules and relationships throughout the lessons helps to enhance students' mastery of basic arithmetic facts. Whitney et al. (2016) assert that this program was successful in improving the students' fact skills as well as other mathematical abilities.

General Technology and Engagement

Technology is another method that can engage students when it comes to practicing and improving fact fluency. In a study comparing two different mathematics interventions, researchers found that the intervention using technology did show more growth. The study included a selection of students who participated in two interventions. One was detect-practice-repair (DPR), and the other was self-mediated iPad instruction (Poncy, Fontenelle, & Skinner, 2013). Students alternated between both activities over the course of three weeks. Results showed that the iPad instruction was more beneficial as shown by post-test data, as well as preferred by all individuals involved (Musti-rao & Plati 2015).

Engagement is a key component when it comes to helping students improve in a skill area. Teaching methods can impact the level of engagement of students. Teacher-student interaction has been shown to help improve engagement during math instruction (Rimm-Kaufman, Baroody, Larsen, Curby, & Abry, 2015). Extra practice and differentiated materials

are beneficial in helping struggling learners grasp concepts more readily, engaging students in their learning, and has a significant impact on their ability to completely master the concept.

Additional Strategies

While some imply that these basic arithmetic skills are "simple" or "easy," teaching these math skills comes with challenges as well as a variety of for how to teach them (Crespo, Kyriakides, & McGee, 2005).When it comes to teaching students mastery of basic facts. These various strategies work differently for all types of learners. This section reviews interventions and strategies most commonly used to help improve fact fluency.

DPR is an intervention involving many components. First students take an initial assessment in order to identify areas of need. Following the pre-assessment, students participate in a series of activities using the cover, copy, compare (CCC) procedures where students are given a fact, read it, cover it, and copy the problem onto a whiteboard. After this, students compare what they have written to the fact card. This method can be used to improve automaticity with specific math facts. Following the CCC procedures, students complete a one-minute drill of math facts and track their progress (Poncy et al., 2013).

The self-mediated iPad instruction program involves students completing a set of math fact problems, and based on their results scored on the iPad, the technology scaffolded practice problems in order for students to practice unknown facts (Musti-Rao & Plati, 2015).

Based on the results from the case study conducted by Musti-Rao and Plati (2015), both interventions showed growth in the students' math fact fluency abilities; however the iPad intervention demonstrated more growth overall. When surveyed students, teacher, and parents also preferred the iPad intervention over DPR due to the features provided through the iPad.

Another mathematic program used in a study to increase mastery in student's arithmetic fact skills is Rocket Math (Smith et al., 2011). Rocket Math is a program that provides students with a series of math facts to master. Prior to beginning the program, students' current ability level is assessed in order for the program to evaluate the speed and accuracy at which students can solve basic math problems. Following the pre-assessment, a variety of worksheets at progressively more difficult levels are provided for each student using the provided Rocket Math resources. As students' progress, they move through the different leveled worksheets to reach a fluency goal. The facts provided in the worksheets include problems the students have already mastered as well as a mixture of unknown problems as well. The program will also only introduce no more than two unknown facts at a time. Based on the results from the study with first grade students, the program was engaging and showed growth in the students' basic arithmetic fact fluency.

Summary

Arithmetic fact fluency is one of the core building blocks required for students to be successful in mathematics. Students need to begin to master facts fluently as early as first grade, and the mastery of these skills typically begins with addition and progresses through subtraction, multiplication, and division. In many classrooms, becoming fluent with arithmetic facts is done through use of flashcards and drill and practice. However, recent studies have shown that engaging students in other related activities facilitates acquisition of and fluency with basic arithmetic facts.

CHAPTER III

METHODS

The goal of this research was to determine which intervention group would be the most successful in helping students to improve their accuracy and speed in solving addition math facts to 20. The null hypothesis is that there would be no effect on students' ability to solve addition math facts to 20 through the use of sending home math facts to practice and 30 minutes on the FASTT Math program a week. Additional interventions at school would have no significant impact on the students' abilities to recall addition math facts to 20.

Design

The research was based on a quasi-experimental design using a pre-test and a post-test. The independent variables were the three intervention strategies. The dependent variable was the additional number of addition math facts students were able to solve accurately in a given amount of time on the post-test compared with the pre-test

Participants

The research for this study was conducted in a suburban elementary school. The treatment group was made up of a class of twenty-one first grade students. The class consisted of 12 males and 9 females. The students in the class have a mixed ability with solving addition facts to 20. The students in the group are six and seven years old. The student population includes nine Caucasian students, four students are Asian, four students are African American, and four Hispanic students. The class is economically and academically diverse.

Instrument

The instrument used was the teacher created pre/post-test. The test includes 20 addition problems with sums up to 20. Students were given 2 minutes to solve as many problems as they could accurately. The same test used for the pre-test was also used for the post-test.

Procedure

The first step to beginning this research was to administer the pre-test to 21 first grade students. Based on the results, students were randomly placed into three groups based on their scores. In order to keep groups fair, I made sure each of the three groups included students with different math abilities. For example, each group had students who scored below 25% on the pre-test, 50% on the pre-test, and 90% on the pretest. This allowed the groups to have a mixed variety of learners.

After students were placed into groups, they were assigned a strategy. All groups received math flashcards which were sent home and assigned to practice 10 minutes a night. The students also participated in the program FASTT Math for 30 minutes once a week. Group A participated addition fact math games three times a week for 15 minutes. Group B participated in flash card practice three times a week. Group C acted as a control and did not receive either of these strategies.

Each week the class received two new sets of addition facts to practice for 10 minutes each night at home. They received the adding 0 and 1 cards first and throughout the six week period the addition facts became more challenging. This was done in order to scaffold students practice at home. Students also utilized the computer program FASTT Math for 30 minutes once a week. This program is individualized for each student and provides them with specific problems based on their ability. Upon signing into FASTT Math students are given a pre-test.

From this data, the program provides students with focus problems and known problems to solve in a given time limit. This program tracks each student's progress and as students master facts, they are given new focus facts to learn.

Over the course of the study, Group A played addition games. The group met in the morning on Monday, Wednesday, and Friday. Every Monday, students were introduced to a new game and played in pairs or groups. The games required students to accurately and quickly solve addition facts to 20 in order to progress. In order provide a variety of games and to keep the students engaged, a new game was introduced each week.

Group B also met three times a week on Monday, Wednesday, and Friday afternoons. The group practiced addition flashcards with sums to 20. A card was presented to the student's one at a time and students were instructed to mentally calculate and share the sum they got. If the student answered the question correctly they kept the card, if they answered incorrectly they waited until their next turn for another problem. This continued until the deck of flashcards was out of cards. Each day, a timer was set to calculate how long it took to go through the deck. The group set a goal to match or beat their time when we met to encourage speed.

At the end of each week, students were given a mini quiz where they solved 10 addition math problem in a 1 minute time period. The problems were related to the flash cards that were sent home that week. This allowed me to track student's progression each week, determine which students were practicing their flash cards at home, and have an idea of which students were making progress. The intervention groups were implemented for a total of six weeks. After the six week period, students were administered the post test.

CHAPTER IV

RESULTS

The purpose of this study is to determine which memorization intervention will improve students' accuracy and automaticity in solving basic addition math facts to 20. At the end of the intervention, students in each group (i.e., sending home math facts to practice, extra time and 30 minutes on the FASTT Math program a week), showed growth in their ability to recall addition mathematics fact fluently. A t-test showed that there was a statistically significant difference between students' average pre- and post-test scores. The value of t is 13.2. The value of p is < 0.00001. Table 1 shows students' pre and post average scores out of 20 (fact test) disaggregated by group.

Table 1

Addition Fact Groups Average Growth and Standard Deviation of Growth

Group	Student Count	Average of Pre-test	Average of Post-test	Average of Growth	StdDev of Growth
A FASST MATH and Games	7	4.14	15.14	11.00	3.74
B FASST MATH + Flashcard Practice	7	4.71	16.29	11.57	3.15
A + B	14	4.43	15.71	11.29	3.34
C Control FASST MATH	7	5.43	14.71	9.29	4.23
Grand Total	**21**	**4.76**	**15.38**	**10.62**	**3.68**

Group A participated in the Fastt Math Program for 30 minutes a week and completed math games 3 times a week. This group began with an average score of 4.14 out of 20 math facts solved correctly in the given amount of time. Following the intervention, this group had an average score of 15.14.

Group B also participated in the Fastt Math Program and did flashcard practice with the teacher 3 times a week. This group correctly solved an average of 4.71 facts prior to the intervention and 16.29 facts after intervention. The control group also participated in the Fastt Math program but did not receive any other sort of intervention. This group began with an average score of 5.43 and ended with an average score of 14.71.

It appears that all the intervention used did create growth in mathematics fact knowledge for students. Further, a One-Way ANOVA showed that the type of intervention used did not have a significant impact on the amount of students' growth between all the groups. All the interventions were equally effective. The f-ratio value is 0.71 with $p < .05$. Further study will be needed. The groups that had additional interventions beyond the Fastt Math Program showed approximately 10% more growth than the Control Group (FASST only group). That is, Group A showed 55% growth (11/20) and Group B had 58% (11.57/20) with the Control Group showing only 46% growth (9.29/20). This additional growth may be an anomaly and additional study will be needed.

Table 2

Summary of Data

Result Details				
Source	***SS***	***df***	***MS***	
Between-treatments	19.8095	2	9.9048	*F* = 0.7099
Within-treatments	251.143	18	13.9524	
Total	270.952	20		

Table 3

Pre and Post Test Scores

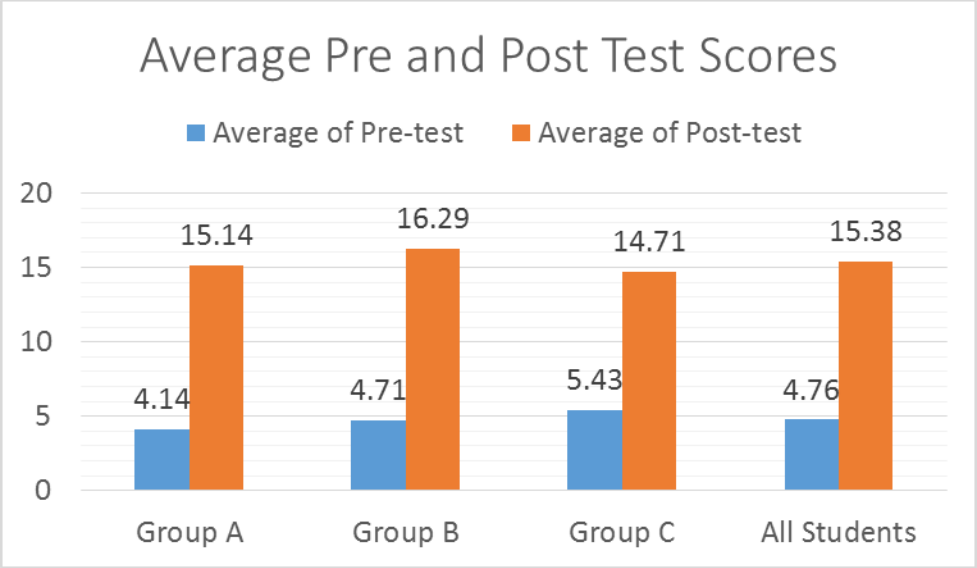

Table 4

. Average Pre- and Post-Test – By Intervention Group.

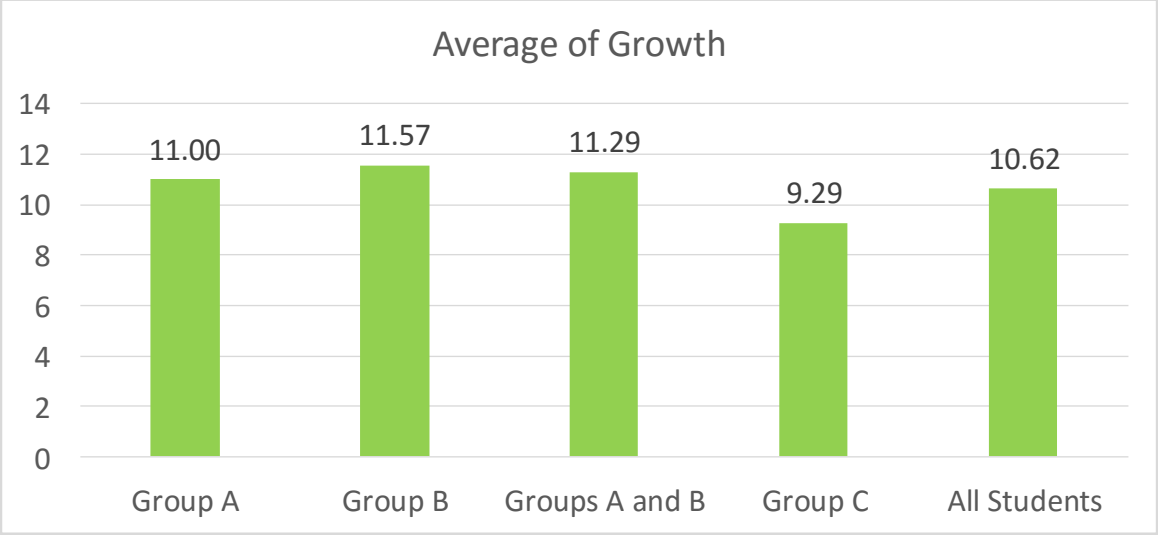

Figure 2. Average Growth by Intervention Group

CHAPTER V

DISCUSSION

The first null hypothesis for this experiment was that students who practice flash cards at home, play mathematics games, or solely participate the facts online with the FASTT Math program will not significantly improve their ability to solve addition math facts to 20 with accuracy and speed. This first hypothesis was not supported for all students regardless of the type of intervention improved their knowledge of addition facts.

The second null hypothesis for this research was that the groups with additional interventions at school will not show more growth. The second hypothesis was supported for the type of intervention the students participated did not matter. The performance of all groups improved including the control group (FASST program alone).

Implications of Results

The results from the experiment show that there were no significant differences among the groups. Both intervention groups and the control group showed improvement. Groups A and B, which participated in games or practicing math facts, did show greater improvement than the Control Group on the post-test. However, the amount of growth was not substantial in comparison.

Theoretical Consequences

The results of the post-test showed that implementing an intervention into math instruction, whether it be an online program, flashcards, or math games, can positively affect a student's ability to recall math facts.

Threats to the Validity

There were some factors that may have threatened the validity of the research and influenced the scores of the post-test. This includes the amount of practice each child completed at home and the student's maturity level. Each student received a set of addition flash-cards to take home. They were instructed to practice 10 minutes a night as part of their math homework. This could have influenced post-test scores because some students may not have practiced as often as instructed, while others may have done more practice at home.

A student's maturity level also may have influenced the overall scores in the research. First grade students are still very young and do not always put forth their best effort when it comes to completing work. This could have affected not only the post-test, but also the student's engagement during the intervention activities.

Connection to Previous Studies and Existing Literature

The results of the research parallel with that of other experiments conducted in examining students' ability to improve math facts. Through the research of Skarr et. al., it was found that students who participated in flashcard practice or engaging math games showed improvement in their math fact fluency (2014). Another researcher also found that the use of online math programs, such as Fastt Math or The Great Leaps math program, helped to build math fluency for students (Whitney et. al., 2016).

Implications for Future Research

If a similar study were to be conducted in the future, it would be beneficial to have more time for the students to participate in their intervention groups. The students were introduced to multiple groups of math facts weekly, and if they were introduced to a set a week, results may

have been different. It would also be interesting in using the data provided by the Fastt Math program to see if it showed similar results to that of the post-test. Since the program follows at the pace of the student, the data the program would have provided would have been different for each student and difficult to interpret.

Conclusions and Summary

Through this research, I have been able to better understand the effects of implementing of different interventions within a math classroom in order to better improve student's abilities to solve addition math facts to 20 fluently and accurately. Overall, it can be concluded that having additional resources, including computer programs, games, and flashcard practice, is beneficial in helping students learn their math facts. However, one intervention was not more significant than the other.

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